TREE SURGERY

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THIS BULLETIN is intended primarily as a guide for those who desire to take care of their own trees or to superintend such work. It outlines some of the better methods of treating injuries, removing dead or diseased limbs, and repairing decayed spots in the trunk or limbs.

A badly diseased or injured tree should be removed and replaced by a healthy one unless there is some very special reason for trying to preserve the tree. This applies particularly to an old tree that has been in poor condition or in poor soil for some years. Such a tree rarely recovers completely from the shock of extensive or elaborate repair work on the trunk; in fact, it often deteriorates more rapidly thereafter. Two axioms of tree-repair work (tree surgery) that should be borne in mind constantly are (1) that prompt treatment of freshly made wounds is the surest and most economical method of preventing disease or decay in the future and (2) that all wounds made in tree-surgery work should be cleaned, sterilized, and protected from infection just as thoroughly as in the case of animal surgery and for exactly the same reasons.

Most persons can, at least with a little preliminary practice on the simpler types of work, undertake any of the work here outlined provided they are familiar with the use of a gouge and mallet, a saw, and a paint brush. A steady head and ability to climb will be necessary for work in the top of a tree.

TREE SURGERY.

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THE DANGER OF NEGLECTED WOUNDS.

INJURIES of various sorts are so common on trees that most people have become oblivious to the danger arising from neglected wounds, or at least they underrate the danger. Every broken limb and every wound that penetrates as far as the inner bark may become the point of entrance of active plant or animal parasites or rot-producing organisms unless these injuries are promptly and properly treated.

The best, safest, and most economical plan to prevent future extensive injury and decay or to prevent the early disfigurement or death of the tree is to attend to all injuries as soon as they occur. This kind of work is comparatively simple and inexpensive. If the injuries are allowed to remain untreated for some years (as they usually are), decay-producing organisms almost invariably enter through the wound and produce rotted areas in the wood, often to such an extent that a violent wind a few years later will break the tree at the decayed and weakened spot. Uninjured bark or an injured area promptly and properly treated usually prevents the entrance of decay organisms.

If an untreated wound of several years' standing has developed a considerable area of decayed wood or bark, the first question to be considered is whether the tree is of sufficient value to warrant the expense of repairing it properly. Should it be decided to repair the tree, the too common mistake of neglecting such portions as are difficult to reach must not be made. A thorough, complete, and sanitary job should be made, or else nothing whatever attempted. If a tree is badly decayed or injured, it is best and safest to remove it and set a healthy one in its place; or it may be braced to prevent breakage in

a violent storm; or it may have the decayed matter removed and the cavity treated in accordance with directions given in this bulletin. Trees from which large areas of rotted wood have been excavated and the cavities filled will rarely completely heal over the filling except under the most favorable conditions. Careful and thorough cavity work on the trunk of a tree is of much greater importance than on a limb, as the latter often may be cut off well behind the diseased area without materially impairing the general health of the tree.

Many people fail to realize the full extent to which properly located, healthy, and well-kept trees will enhance the value of real estate, particularly for residential use. From this point of view alone, it usually is best to keep the trees in a healthy and vigorous condition. Oftentimes, historical association, scientific value, or rarity of the species outweighs all other considerations. Trees unquestionably are a real asset from various points of view and for reasons too well known to need mention here.

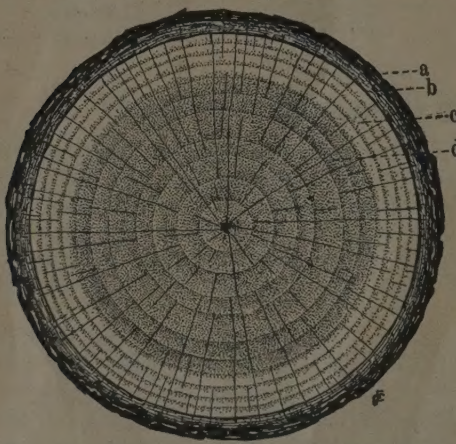

FIG. 1.—Cross section of a typical tree trunk, showing the various parts: *a*, Bark; *b*, cambium; *c*, sapwood; *d*, heartwood. The concentric rings in the sapwood and heartwood are the annual rings. The radial lines extending part way or entirely from the center to the bark are the pith rays. In this figure the outer and inner bark are represented as approximately equal in thickness.

When owners of trees realize more fully than at present that it costs comparatively little to properly treat injuries at the time they are made and that such treatment means much to the health, beauty, usefulness, and value of the trees in years to come, they will have learned the greatest economic lesson connected with the care and repair of trees.[1]

THE CAMBIUM.

The trunk and branches of a tree are made up of a cylinder of wood surrounded by bark. (Fig. 1.) Between the bark and the wood on healthy parts of the tree there is a very thin continuous layer of young (embryonic) tissue, which is not necessarily sharply marked

[1] For advice in selecting trees and shrubs for the home grounds, see Farmers' Bulletins 185 and 1087 and Department Bulletin 816.

off from either wood or bark. This is the cambium (fig. 1, *b*). It is this layer that splits or slips so easily in the spring time, when the bark is removed to make the familiar willow whistles of boyhood days. During the growing season its microscopic elements (cells) are constantly dividing and giving rise to new layers of cells on both sides, on the outer side of the cambium to new layers of bark, on the inner to new layers of wood. Thus, the youngest layers of both wood and bark are those adjoining the cambium. As the cambium is a very tender and thin-walled tissue, a comparatively slight injury will kill portions of it, and once killed the dead area never again can give rise to new bark or new wood. However, the healthy living cambium around the edges of the dead area will give rise each year to a new layer of more or less abnormal wood and bark unless its growth is retarded by disease or subsequent injury. Under normal conditions these new layers of wood and bark (called callus wood and callus bark) grow out each year over the margin of the dead area a little more than the width of an annual ring (see fig. 1), and eventually the dead area, if not too large, may be entirely overgrown or hidden from view. Such dead spots furnish favorable points for the entrance of insects and organisms causing decay unless they are properly treated.

All new layers of the normal wood and bark of roots, trunk, and branches originate in the living cambium, never elsewhere; consequently, it is of the utmost importance to keep the cambium in a healthy and uninjured condition at all times. Diseases or injuries that kill the cambium or large portions of it usually are fatal to the tree.

REPAIR WORK.

In repair work (tree surgery) a few fundamental principles must be observed in order to secure permanently good results. These may be summarized briefly as follows:

(1) Remove all dead, decayed, diseased, or injured wood or bark. When on a limb this can often be done best by removing the limb entire; on a large limb or on the trunk it may mean at times digging out the decayed matter so that a cavity is formed.

(2) Sterilize all cut surfaces.

(3) Waterproof all cut surfaces.

(4) Leave the work in the most favorable condition for rapid healing; this will often mean filling or covering deep cavities.

(5) Watch the work from year to year for defects, and if any appear attend to them immediately.

SOME THINGS TO BE AVOIDED.

The careless use of a long pruning hook or other implement to break off small dead twigs should be avoided, as every bruise may become the point of entrance of disease or decay. Climbing spurs produce wounds that are very easily and frequently infected. Spurs

should never be used except on a tree that is to be removed or destroyed. A man who insists on using climbing spurs in tree-surgery work should never be allowed to work on trees. Nails and leather soles and heels on shoes often cause injury. Rubber-soled tennis shoes, or "sneaks," or some similar soft-soled shoe that will not slip should be used in tree-surgery work.

SURGERY WORK.

The simplest type of tree-surgery work consists in removing dead or dying limbs or neglected or decayed stubs and in treating the wounds with antiseptic and waterproof coverings to prevent the entrance of decay-producing organisms and moisture while healing. A more complicated type consists in digging out the decayed and diseased wood of decayed spots and treating the freshly cut surfaces of the cavities with antiseptic and waterproof coatings and also in filling the cavities with suitable material. Artificially filled cavities do not increase the strength of the trunk or limb to the extent that is commonly supposed. An improperly filled cavity is always a greater menace to a tree than an unfilled one.

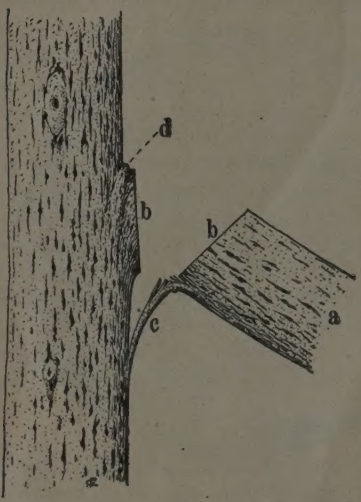

FIG. 2.—The wrong way to remove a heavy limb. A single cut from the upper side usually makes a long wound below the scar where the bark and outer wood are stripped: *a*, Limb; *b*, saw cut that severed the limb; *c*, strip of bark and wood stripped from the trunk; *d*, shoulder of the limb.

REMOVING BRANCHES.

The work of removing branches primarily includes the removal of healthy, dead, or diseased branches when the decay or disease does not extend back on the branch as far as the point where it is to be cut off; that is, the cut is made entirely through healthy wood.[2] This type of work can be regarded as comprising two essential operations: (1) Removing the branches in a manner that will prevent injury to the surrounding bark and cambium and (2) shellacking, sterilizing, and waterproofing the scars.

The most essential implements for removing large branches are a good-sized saw with teeth so set as to make a wide cut, a gouge, a chisel, a mallet, a strong sharp knife, and an oilstone. For cutting

[2] If decay runs back into the trunk, it will be necessary to excavate all decayed matter, following the directions given later under "Cavity work."

limbs near the ground, these are the only necessary implements, though others often may be convenient. For limbs situated elsewhere, one or more ladders may be needed; also, at times, a rope.

A large limb rarely should be removed by a single saw cut from the upper side, as this usually strips the bark and wood below the scar as it falls (fig. 2) unless handled as described later. A preliminary cut should be made on the under side, usually from 6 inches to a foot beyond the point where the final cut is to be made. It should reach from a quarter to half way through the limb (fig. 3, *a*). A good time to stop cutting is when the saw becomes pinched in the cut. A second cut should be made on the upper side of the limb, an inch or more beyond the first one (fig. 3, *b*) and continued until

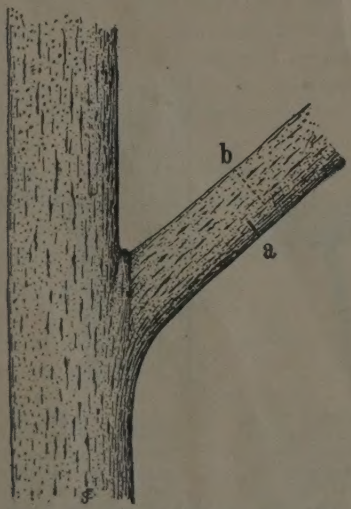

FIG. 3.—The right way to remove a heavy limb. The first cut is made on the under side of the limb, at *a*. The second cut is made at *b*, this cut being continued until the limb falls.

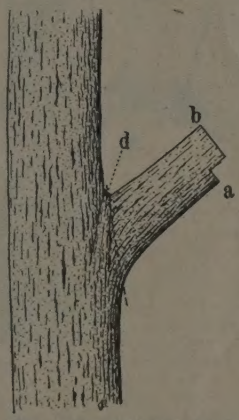

FIG. 4.—The right way to remove a heavy limb. The third cut is made close to the trunk so as to leave no projecting stub. Both *a* and *b* are the same as in figure 3; *c* indicates the position of the third cut; the shoulder of the limb is shown at *d*.

the limb falls. A third cut, to remove the stub, should then be made close to the trunk (fig. 4, *c*). When nearly severed the stub must be supported so as to avoid any possibility of stripping the bark on the trunk as it falls. The first and second cuts may be omitted when a limb is so small that it can be held firmly in place until completely severed. If desired, the edges of the scar may be smoothed with a sharp chisel to conform to the trunk.

A large limb often can be removed safely with a single downward saw cut close to the trunk if handled as shown in figure 5. It is bad practice, as well as a menace to the tree, to leave a projecting stub (fig. 6). The scar should be pointed at both ends (fig. 7), as this is the most favorable shape for satisfactory healing.

A coat of good shellac should be applied with a suitable brush over the entire cut edge of the bark, the adjoining outer sapwood, and the cambium immediately after the cut is made, or at least as soon as the cut surfaces are sufficiently dry. This is to prevent any appreciable drying out and consequent dying back of the cambium. If the cut has not been made through perfectly healthy wood, the wound should be cut back until sound healthy wood is reached. Usually it is unnecessary to shellac more than a quarter of an inch on either side of the cambium. If the scar is a large one, a sharp knife or drawshave should be used along the margin for one or two minutes, and then the freshly cut surfaces shellacked, repeating the

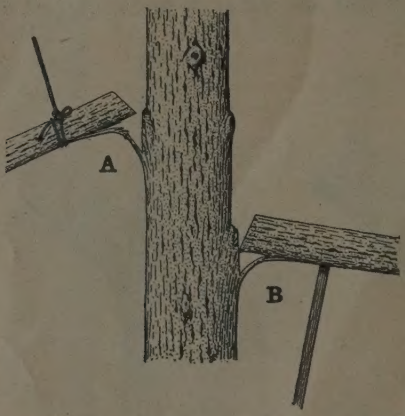

FIG. 5.—A heavy limb can often be removed safely with a single downward saw cut by supporting the limb with a tightly drawn rope, as shown at *A*, or by a firmly placed heavy prop, as shown at *B*. Both rope and prop should, if possible, be so slanted as to cause the limb to swing away from the trunk as it is severed. If the rope is tied to a living overhead branch, the latter should be well padded to prevent injury.

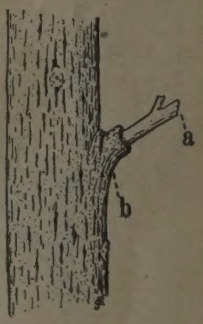

FIG. 6.—A projecting stub of decaying wood which has become a menace to the living parts adjoining. This limb was cut at the point marked *a;* it should have been cut at *b*.

operation until all the bark and outer sapwood encircling the scar have been shellacked. The maximum benefit from shellacking is not likely to be realized if the freshly cut surface is allowed to remain dry and without shellac for more than 3 or 4 minutes.[3]

STERILIZING AND WATERPROOFING THE WOUNDS.

Many sterilizing preparations have been used with more or less success. Ordinary commercial creosote (a coal-tar product, some-

[3] The shellac brush can be cleaned readily at any time by working it around for a few minutes in a can of water in which a little borax has been dissolved. It is then rinsed in clear water and dried. The shellac can be conserved while in use by having the handle of the brush fitted tightly through a hole in the cover of a friction-top can, the cover not being removed from the brush when the latter is used to spread the shellac.

times called creosote oil), apparently is one of the best preparations for destroying and preventing the growth of certain wood-destroying fungi. It can be applied with an ordinary paintbrush and should cover every part of the exposed wood which has not already been covered by the shellac. The entire shellacked and creosoted surface should finally be waterproofed with thick coal tar or asphalt.[4] A single application of a mixture of creosote and coal tar (about one-fourth or one-third creosote) to cover the entire scar has been quite extensively used with good results. A better mixture is made by melting asphaltum and mixing with it an equal quantity (by weight) of creosote.[5] If too thick to apply when cold, add more creosote and stir. Asphalt, without creosote, is an excellent waterproof covering and doubtless would be more generally used were it not necessary to apply it hot. Paint frequently is used for waterproofing but is less permanent.

FIG. 7.—If the shoulder has been removed and the upper and lower ends of the scar are broadly rounded or square they should be pointed, as indicated by the broken lines. If the shoulder (see figs. 2, *d* and 4, *d*) has not been removed the pointing of the scar is not so important, and at times it is unnecessary.

Creosote and tar at times will cause slight injury when used around wounds on certain trees, especially cherries, peaches, and plums. Except on magnolias and tulips such injury has not been especially noticeable on most of our common shade trees. If injury from the use of creosote and tar is feared or suspected a moderately blue solution of copper sulphate in water[6] or 1 part of corrosive sublimate in 1,000 parts of water[7] may be used as an antiseptic wash. As soon as this is dry the wound can be painted with any good lead paint.

Grafting wax (particularly thick liquid alcoholic grafting wax) is excellent for waterproofing small surfaces.

Another good method of treating the scars is to char the surface with a gasoline or alcohol blast torch and then quickly cover the hot

[4] For applying hot asphalt, use a cloth swab or a brush made of broom corn, as the bristles of an ordinary brush are usually quickly destroyed by the hot asphalt.

[5] It usually is necessary to set the kettle or pail containing this mixture in a larger kettle of boiling water for an hour or more, in order to completely dissolve the asphalt. As creosote is inflammable, care should be taken that it does not come in contact with the flame, as might happen if the heating were done directly over an open fire.

[6] 1 pound of copper sulphate in 3 or 4 gallons of water.

[7] Corrosive sublimate (or bichlorid of mercury) is a deadly poison to man or animals if taken internally and is a caustic or corrosive agent on the skin or on metals. The 1 to 1,000 solution can be made most readily by purchasing the 7 or 7.3 grain tablets of bichlorid of mercury at a drug store, where they are sold subject to laws governing the sale of poisons. One of these tablets dissolved in a pint of water will make a solution of the proper strength. The solution should be freshly mixed for the best results. Usually it will retain sufficient strength for ordinary use for two or three months. If placed in an amber or blue bottle away from the light, it will keep at least two or three times longer. As a precautionary measure against the accidental poisoning of domestic animals, the discarded solution should be buried rather than poured into a sink drain or thrown out on the surface of the ground. Solutions should not be kept in metal containers, nor should brushes with metal coverings or wire-fastened bristles be used for applying it, as the solution promptly corrodes all metal with which it comes in contact.

surface with heavy tar, pitch, or hot asphalt. Heat is an excellent sterilizing agent, but it kills back the cambium considerably.

On particularly choice trees, where the black color of tar or asphalt is objectionable, the scar can be sterilized with the corrosive-sublimate or copper-sulphate solution and, as soon as dry, shellacked. After a week or two the shellacked surface should be painted with spar varnish. For many purposes and on many trees this treatment is particularly satisfactory. If the scar is clean and healthy and not located near any former area of decay or disease, the sterilizing washes may be omitted and the shellac applied directly to the unsterilized scar. The alcohol in the shellac is a good sterilizing agent. If it is desirable that the scar be colored to match the bark, a suitably colored coat of paint can be applied over the shellac and allowed to dry before the coat of spar varnish is applied, or the spar varnish may be omitted.

Permanently good results from waterproofing can be secured only when the treated surfaces are watched from year to year and recoated annually or biennially, especially when any tendency of the coating to crack or peel is observed. This is an important part of the work, a part which is commonly neglected. It is best to recoat the wounds regularly every year or two, even though no cracks appear.

The healing of wounds by means of new callus growth at the sides is usually more rapid if neither paint nor other generally used waterproof covering is applied (shellac excepted). However, the rapid healing of the wound is of secondary importance to that of preventing the entrance of decay-producing organisms. To prevent decay is one of the most important and essential considerations in tree surgery. It is of vital importance in the care of long-lived trees. With short-lived trees it obviously is of less relative importance.

One of the best (though little used) methods of counteracting the danger arising from cracks in large flat scars, particularly scars that are sound and healthy, is to cover the freshly waterproofed wood of the wound with sheet metal, heavy tarred paper, or heavy cloth, firmly tacked down and waterproofed.[8]

For the work of removing small branches a saw, a sharp strong knife, a hand pruner, and a long pruning hook will be the most useful implements, in addition to some of those already mentioned. In removing small branches and twigs the cut should be made as close to the surface of the supporting branch as possible, so as to leave no projecting stub (see fig. 6). A sharp knife is the best tool for the work and should be used, when possible, in preference to the hand pruner or pruning hook. When the hand pruner is used the cutting blade should always be turned toward the tree, so that the

[8] For a detailed account of this method, see the Weekly News Letter of the United States Department of Agriculture for February 9, 1916.

supporting bar makes its bruise on the part that is cut away. The long pruning hook should be used with caution and only when the place to be pruned can not be reached with the knife or hand pruner. For protection against possible infection, the pruning wounds must be sterilized and waterproofed in some such manner as that recommended for larger branches. For very small wounds shellac may be as handy to use as any preparation. Liquid grafting wax or shellac is particularly satisfactory for scars less than a half inch in width on choice trees or shrubs or on those that are susceptible to injury from the use of tar or creosote.

The statement has often been made, and very widely accepted, that it is not necessary to paint the scars made by cutting small branches, a half inch or less in diameter; but the writer has observed many instances where serious diseases have gained entrance through wounds that were considerably less than half an inch across. For thorough and careful work, particularly on choice trees or shrubs, the smaller scars should be as thoroughly treated as the larger ones.[9] Care should be taken, however, that the waterproof covering is not applied to the surface of the uninjured bark adjoining the wound, as this may cause injury through partial asphyxiation.

CAVITY WORK.

When an injury or wound has been allowed to remain untreated for a year or more, decay-producing organisms are almost certain to have started an area of decay behind the exposed surface of the wood. If untreated, this area increases in size and depth as time passes, until in the course of years it so weakens the limb or tree that a storm may break it at the weak point, or the decay may have developed to such an extent that any attempt at treatment would be a waste of time and money. Such areas of decay often are aggravated and increased by the presence of insects, particularly borers and ants. All such regions of infection or decay must be attended to promptly if the best possible results are to be realized. Whatever may be the size of the decayed or diseased area or wherever it may be located, the first steps toward checking its progress are practically identical in all cases. They may be regarded as comprising two essential operations: (1) Excavating all decayed and diseased wood and (2) sterilizing and waterproofing all cut surfaces.

TOOLS.

The necessary tools for digging out the decayed wood are few. As a rule, two outside-ground socket-handled gouges,[10] a chisel, a mallet, a knife, and an oilstone are sufficient for ordinary work.

[9] Small scars near the ground, such as those of small branches, are not usually a source of great danger, for if infection takes place it is possible to cut off the small branch or later to check it without seriously disfiguring the tree.

[10] One gouge should have a curved cutting edge of about three-fourths of an inch and the other perhaps 1½ inches.

The gouges, chisel, and knife should never be used on the bark or near the cambium when they lack a keen edge, as dull tools will injure the latter. In cutting out deep cavities, longer interchangeable handles for the gouges may be necessary. A ladder or a step-ladder will be required if the work is more than 5 or 6 feet from the ground. As the work progresses, the desirability or convenience of certain other implements will often become evident.

EXCAVATING.

Usually an old neglected area of decay may be partially or wholly covered at the edges by a comparatively recent growth of wood and bark, and the visible area of decay may be small as compared with the part which is hidden (fig. 8). Indeed, this is the usual condition. In such cases it often is necessary to enlarge the opening in order to have sufficient room in which to gouge out the interior. This opening should not be made any wider than is necessary, but it may be sufficiently long to reach all the decayed and diseased heartwood with little or no additional injury. If the decayed and diseased wood extends some distance above or below the external opening it will be necessary to lengthen this opening in order to reach all the diseased wood. The opening should be pointed at both ends.

FIG. 8.—Section of a tree with an old wound partially healed over, showing a large decayed area (*a*) with only a small opening (*b*) visible from the exterior. In excavating the decayed area the cavity should reach back in all directions into sound wood.

The most important feature at this stage of the work is to remove all the diseased or insect-eaten wood. This excavating must continue on the sides and ends of the cavity until sound and uninfected wood is reached. All discolored or water-soaked wood should be removed, as this is the region in which the rot-producing fungi are usually most active. Infected wood usually extends some distance above and below the visibly discolored portion. In decayed areas of many years' standing there may be only a thin shell of healthy wood around the cavity, in which case there is danger of the tree being broken by storms unless braced or guyed, as mentioned later (pp. 25–27). Unless there is some very special reason for attempting to prolong the life of such a tree it is better to have it removed and replaced by a healthy one. If desired, a comparatively large tree can be moved in to replace it. In experienced hands the transplanting of large trees can now be done with reasonable assurance of success.

SHAPING THE CAVITY.

Whenever possible, the bottom and all other parts of the cavity should be shaped so that any water thrown into the cavity will run

out promptly and none remain in any hollow. When the cavity extends below the surface of the ground (rarely at other times), it is not possible to drain it in the manner mentioned. Under such conditions the lower part of the cavity should be filled to a few inches above the level of the ground and the top of the filling sloped so as to throw the water out of the cavity in case the whole cavity is not to be filled.[11]

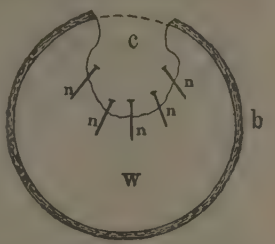

FIG. 9.—Section of a tree cavity, showing how it is undercut at the margins to assist in holding a plastic filling in place; it also shows nails driven into the back of the cavity for a similar purpose: *b*, Bark; *c*, cavity; *n*, nails; *w*, wood.

It is bad practice to have a deep water pocket at the bottom of a cavity with drainage provided through an auger hole bored from the exterior. An open hole of this sort usually becomes a favorable lodging place for insects, fungous spores, yeasts, and bacteria, any one of which may cause trouble.

As already emphasized, great care must be taken in working around the cambium, and all cutting tools must be kept very sharp. The final cutting along the edges of the bark and sapwood can often best be made with a very sharp knife or drawshave. This cutting must be followed immediately by a coating of shellac, which should cover the cambium and a narrow strip of the bark and adjoining sapwood (see p. 8).

FIG. 10.—Section of a tree cavity, showing how strips of wood (*a*) can be nailed along the edges to prevent the inrolling of the new callus growth and at the same time to hold a plastic filling more firmly in place. In open cavities the back edge of the strip should be beveled, as indicated, so as to allow ready inspection of all parts of the cavity; in cavities to be filled the back edge should not be beveled.

UNDERCUTTING.

Another point to be borne in mind in shaping a cavity that is to be filled with cement, asphalt, or other similar substances is to have the sides undercut if possible (fig. 9), so as to hold the filling more firmly in place. Care must be taken, however, that the living wood at the edges of the opening is not very thin, as this promotes the drying out of the sapwood and bark at these points. Ordinarily the edges should be at least three-fourths of an inch thick (1½ inches is better). When possible it should include the full thickness of the sapwood. Inrolled bark at the edges of an opening should be cut away. If it is not possible to undercut sufficiently to hold the filling firmly in place, the alternative method described under "Nailing or stapling" can be adopted, or one or more strips of wood can be nailed around the cavity, the outer surfaces of which are level with the cambium (fig. 10).

[11] Asphalt and sawdust (or sand) make one of the best mixtures to use in such places. See pp. 20-22.

STERILIZING THE CAVITY.

After the decayed and diseased matter has been completely excavated and the edges of the sapwood and bark adjoining the cambium shellacked, the remainder of the cavity also must be sterilized. As already stated (pp. 8–9), creosote appears to be one of the best generally known preparations to use. Every exposed part of the wood and bark must be sterilized, and over this a heavy coating of tar, hot asphalt, or some other suitable waterproof covering applied.

This completes all the essential operations in repairing and treating old decayed spots or freshly made injuries. Filling a cavity is of much less importance. Oftentimes a cavity is safer and better if left unfilled; it certainly is if cement is used and the work is done carelessly or ignorantly.

OPEN CAVITIES.

A tree cavity which has been excavated, sterilized, and waterproofed in the manner just described is in condition to be left, with occasional inspection, in comparative safety for years. Cavities treated in this way probably are safer than most tinned or cemented cavities of the ordinary sort, and, furthermore, they have the advantage of permitting easy inspection from time to time. The new growth of wood and bark along the margins will gradually form an inwardly rolled edge if there is no filling, sheet metal, or artificial ledge (see fig. 10) to force it across the cavity.

The cavity must be watched from year to year, and any tendency of the waterproof coating to crack, peel, or blister should immediately be counteracted by repainting. This is an important point, which must not be neglected. It is better and safer to repaint every year (or at least every two years) until healed over, without waiting for defects to appear.

TIN-COVERED CAVITIES.

Sheet tin, zinc, and iron have been used rather extensively to cover cavities. When properly applied, these coverings assist in keeping out disease, decay, and insects for a long time. If improperly covered or if the cavity itself is not properly treated, a metal-covered cavity is a much greater menace to a tree than an open one. In preparing a cavity for a sheet-metal covering, all the decayed, diseased, and insect-eaten wood should be removed in the manner already explained, with two modifications: (1) There is no necessity of undercutting the cavity and (2) there should be a narrow half-inch ledge of wood around the edge of the cavity from which the bark has been removed and to which the margin of the sheet metal can be tacked (fig. 11). The cavity must be thoroughly sterilized and waterproofed, as already described. The sheet metal should be trimmed so that its edges will fit closely along the edges of the live bark. This

can best be done by first making a heavy-paper pattern. The metal should be cut the same shape as the paper pattern and then placed on a block of wood and holes a half inch or an inch apart punched or drilled along its margin, through which long, slender, flat-headed brads may be driven into the ledge of wood around the cavity. The edges of the cavity and the inner side of the metal should be freshly waterproofed (the entire cavity already having been so treated). The metal should be put in place and nailed with a light hammer, allowing it to curve outward so as to conform to the general shape of the trunk or to curve inward. Two or more pieces of sheet metal with overlapping joints should never be used unless these joints are soldered air tight. If all insect tunnels have not been cut out, the cavity should be fumigated by saturating a wad of cotton or cotton waste with carbon disulphid[12] and suspending it with a string in the top of the cavity for 12 hours or more before the metal is permanently nailed to the wood at the top. During the fumigating process the cavity must be tightly closed. The final operation is to waterproof the outer surface of the metal, taking special care that the tacked edges are made as air tight and waterproof as possible. During all parts of the operation care should be taken that the cambium is not bruised or unnecessarily cut.

FIG. 11.—Section of a tree cavity, showing the marginal ledge of wood (*a*) to which a sheet of metal (*b*) can be tacked to cover the cavity.

BOLTING THE CAVITY.

If a long cavity is to be filled with cement or asphalt it usually is advisable to place through it one or more bolts to hold the wood and filling more firmly together. A cavity 2 feet or less in length will not usually require a bolt, but long cavities as a general rule should be bolted every 18 to 24 inches. Oftentimes a single bolt can be placed so as to support both sides (fig. 12). In certain cavities it may be necessary to place bolts at different angles (fig. 13). In any case a strip of uninjured bark and cambium at least an inch wide should be left between the edge of the cavity and the end of the bolt. On medium-sized trunks, after deciding where the bolts can most efficiently be placed, a sharp bit, a half-inch (or larger) in size and sufficiently long to reach through the trunk and cavity, can be used to bore the hole for the bolt. On large trunks a larger bit should always be used. Iron or steel washers (preferably oval) about three times the diameter of the bolt (fig. 14) should be countersunk into the wood by carefully cutting away the bark and wood at both ends

[12] Carbon bisulphid should not be used near a fire or open light, as under such circumstances it is explosive. See Farmers' Bulletin 799, entitled "Carbon Disulphid as an Insecticide."

of the hole. The washers should be heavy and ample, but not so broad as to necessitate cutting away an excessively large piece of bark. In most trees when round washers are used it is advisable to have the bark adjoining this countersunk area somewhat pointed above and below the washer (fig. 15), for reasons already mentioned. By holding the two washers in place, the length of the iron or steel

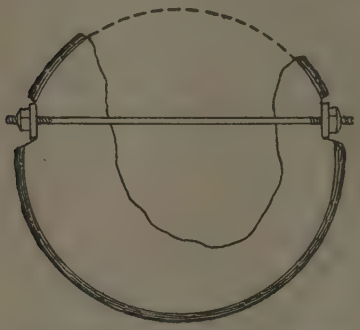

FIG. 12.—Section of a large tree cavity, showing how a single bolt should be placed to hold the sides rigid.

FIG. 13.—Section of a large tree cavity, showing how two bolts should be placed to hold the sides rigid.

machine bolt needed can be determined by measuring through the hole. The bolt must be thick enough to fit snugly in the hole and should project beyond each washer for at least a quarter of an inch. The thread at each end of the bolt must be coarse and sufficiently long to permit drawing in the sides of the cavity as the nuts are screwed up firmly against the washers. A chamfered single-headed bolt may be used, if preferred. Before the bolts are finally put in place the countersunk cuts and the bolt holes should be tarred or creosoted, and after the bolts are in place all exposed parts of the bolts and nuts should be waterproofed. If the washers and nuts are sunk deeply into the wood the holes at the ends of the bolts may be filled with cement or asphalt to the level of the cambium. This will make a neater looking job and leave the spot in better condition for healing.

FIG. 14.—The ends of two bolts with oval washers. The long diameter of the washers should run lengthwise of the trunk or limb.

All split cavities must be securely bolted, particularly near the upper part. If the split comes from a crotch, all decayed and diseased wood should be removed from the split and an antiseptic wash and waterproof coating applied, after which it can be bolted just beneath the crotch (fig. 16, *a*) so as to close the crack or at least bring the parts back to their normal position in case decayed matter has been excavated from the crack. If the split is a recent one, an antiseptic washing alone will usually be sufficient before drawing the

sides together with bolts. Under most conditions, particularly in large trees, it will be necessary to use a rope and tackle blocks some distance above the crotch to pull the limbs together so as to properly close the crack before bolting it. When tackle blocks are used care must be taken to have an abundance of bagging or other padding between the bark and the encircling ropes. Finally, all exposed edges of the crack must be thoroughly waterproofed. If necessary, limbs above split crotches may be guyed, as described later. If there is a cavity in the crotch, it should be cleaned and the limbs above it firmly guyed before the cavity is filled.

FIG. 15.—The end of a bolt with a round washer. Triangular pieces of bark should be cut away above and below the washer, as indicated by the broken lines.

FILLING CAVITIES WITH CEMENT MIXTURES.

If desired, cavities made by excavating decayed material may be filled with any one of a variety of substances. The most important purpose of the filling is to prevent the new growth of wood and bark from curving or rolling into the cavity and not to strengthen the trunk, as many people suppose. At present the most widely used material for this purpose is cement, usually in the form of cement mortar or concrete. There are many theoretical and practical reasons why the use of cement should be avoided, or at least discouraged. The use of cement in long or large cavities, either in one solid piece or in sections, is not advocated. Under ordinary conditions such cavities had better be left open or filled with asphalt or wood. However, cement appears to hold fairly well in small or globular cavities in the trunk and larger limbs that are not easily bent by a high wind and in somewhat larger cavities about the base of the trunk or in the roots; that is, where there is little or no movement as the tree sways in the wind.

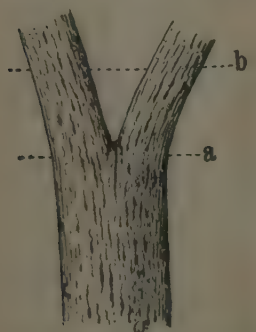

FIG. 16.—A split crotch. The dotted lines *a* and *b* indicate the position in which bolts should be placed to hold the split.

If for any reason it becomes necessary or desirable to fill a long or large cavity with cement, the cavity may be fitted with rods, bolts, or wires for reinforcing the cement when the latter has been placed in the cavity, or iron girders may be firmly bolted into the cavity to stiffen the trunk. There are various ways of reinforcing, the choice of methods depending largely upon the location, size, and shape of the cavity. One simple method of doing this is to drive heavy staples along the sides of the cavity, from 4 to 8 inches apart and 3 or 4 inches back from the cambium. Between these staples heavy wires are stretched across the cavity, crisscross or straight. Another simple method is to use

a few iron rods, the ends of which are set into holes bored into the wood. Straight rods can be bent in order to insert the ends in the holes and then straightened, or one end of the rod can be bent at a right angle and the long end inserted in a hole at the top or bottom of the cavity and the short end in a properly located hole at the back or side of the cavity. One rod or several such rods may be used, as seems desirable. At other times it may be preferable to place a few bolts through the cavity. Bolts have the advantage of holding the sides of the cavity rigidly in place against the hardened cement. The bolts should be placed in accordance with the instructions given on pages 15 to 17.

The method of preparing cavities for filling with cement is the same as that already described (p. 12).

Nailing or stapling.—In a cavity with a comparatively large opening or with little or no undercutting it is common to drive flat-headed wire nails or large staples for half their length into the wood in the interior before inserting a plastic filling. In medium-sized cavities large staples or nails 2 or 3 inches long may be driven into the wood for about half their length (fig. 9). The loops of the staples or the heads of the nails finally are completely embedded in the hardened filling, thus preventing the filling from falling out of shallow cavities under ordinary strain.

Mixing the cement.—A good grade of Portland cement and clean sharp sand free from loam (1 part of cement to 3 or less of sand) should be used. The mixing can be done in a mortar bin, a wheelbarrow, a pail, or in any other available receptacle that is sufficiently large. A quantity of dry cement and sand sufficient to fill the cavity should be thoroughly mixed before adding water to make a stiff mortar and the whole mixture worked to an even and smooth, but not watery, consistency. In cavities a foot or more in diameter, fine gravel free from loam is sometimes substituted for the sand except near the outer surface.

Filling the cavity.—For placing the mixture in the cavity a mason's flat trowel and an ordinary garden trowel with a curved blade will be found convenient. A tamping stick 1 or 2 inches thick and 1 to 3 feet long, depending on the size of the cavity, will be needed. A layer of cement 2 or 3 inches deep can now be placed in the bottom of the cavity with the trowel and tamped firmly in place. This operation is repeated until the cavity is filled, the tamping being directed mainly toward the back of the cavity rather than downward. If the mixture is too moist, it will tend to run out at the bottom of the cavity under the operation of tamping. If too little water has been used, the mixture will be somewhat granular or powdery and will not pack down promptly. The remedies are obvious. If the interior of the cavity extends well above the level of the external

opening, it may occasionally be necessary to bore or cut a downward slanting hole from the outside to the top of the interior cavity, through which a watery mixture of cement may be poured to fill the upper part of the cavity and the hole. The main opening of the cavity must be completely closed with the stiffer cement and allowed to partially set before this watery mixture is introduced. When the cement has partially set, the outer surface should be carefully smoothed or cut down with the flat trowel to the level of the cambium, as shown by the dotted lines in figures 9, 12, and 13, taking great care that the latter is not injured in the operation. If the cement is allowed to set too firmly to trim with the trowel, it can still, with more or less difficulty, be cut back to the cambium line with a cold chisel and hammer.

The thinner mixtures of cement will set more firmly. If a mixture thinner than the one indicated above is used to fill a cavity, some sort of cloth or wire dam will have to be used to hold the cement in place until it is set. It may be convenient to use such a dam on all except cavities with small openings. One simple method is to wrap strips of burlap around the tree so as to cover the lower part of the opening, if the mixture is not very thin; otherwise, a more closely woven fabric, such as canvas or carpet, may be used. This dam at first should cover only the lower part of the opening, and should be loose enough to allow it to be pushed outward to about the normal contour of the trunk when the cement is tamped in place behind it. The cavity is filled with cement to the top of the dam and the height of the dam increased as becomes necessary by wrapping more cloth or wire about the tree without disturbing that already in position. After the cement has partially set but before it has become hard, the dam is removed and the surface of the cement trimmed back with the mason's trowel and finished in the usual manner. At times it is advisable to have wire netting of about a half-inch mesh or wires (or metal rods embedded in the cement) nailed to the sides of the cavity to reinforce the filling and hold it in place.

The edges of cement fillings in the crotches of limbs are especially difficult to keep water tight. Besides bolting the cavity and guying the limbs above it, the crevices at the edges of such cement fillings must be made as near absolutely waterproof as thick tar or asphalt or elastic cement can make them. A mixture of asphalt and sawdust is much better than cement to use as a filler in such locations.

After a cement filling has become thoroughly dry, the outer face may be painted with coal tar or paint. If cracks appear in the cement, or the wood draws away from the cement, or the work is not properly done, decay-producing organisms may gain entrance at the edge of the cement and cause serious trouble.

FILLING CAVITIES WITH ASPHALTUM MIXTURES.

For covering large wounds or for waterproofing cavities, asphaltum (commonly called asphalt) apparently is not equaled by any other substance that has been mentioned in this bulletin. The asphaltum referred to is a product of the distillation of some of the western petroleums and varies in melting point from the boiling point of water upwards. The greatest objection to its use is the fact that it has to be kept melted and used while hot. This makes the process cumbersome and inconvenient, which in itself is a serious objection from many points of view, although a coating of asphalt, properly applied at the outset, will often last for years without special attention. For normal scars it should be used clear and applied with a swab or small whisk broom.

As an efficient cavity filler asphalt has few of the objections found in cement, because its elasticity and resilience prevent cracking and it is absolutely waterproof. It is very adhesive and does not readily separate from the wood when properly applied. For filling a cavity it should not be used clear but in combination with dry sawdust, wood pulp, excelsior, shavings, sand, or some other substance.

An outline of two methods of using a mixture of asphalt and sawdust to fill a cavity will serve in general for the other mixtures mentioned. The first method will be most useful when a fire or stove can be used near the tree, and the second where this is impracticable, as, for example, on a well-kept lawn or near shrubbery that might be scorched by the heat.

First method.—Thoroughly melt the asphalt in a kettle or other suitable receptacle and slowly stir in the dry sawdust. Continue adding the sawdust as long as the particles are blackened by the asphalt after a few moments' stirring. This hot pasty granular mixture can then be placed in the cavity, which has been prepared as already described, and pressed or tamped into close contact with the side of the cavity before it hardens or cools. For placing the mixture in the cavity, which already has been waterproofed with clear hot asphalt, a trowel, paddle, or ladle can be used. The tamping stick should have a smooth and slightly rounded end. The end may be covered with sheet metal if desired, or a tamping rod made of iron may be used. If the mixture adheres to the end of the tamping stick to an extent that interferes with the work, a quick twist, as it is about to be withdrawn, will usually improve conditions. It may be necessary to grease or wet the end of the stick frequently. Often the best results are realized when a steady slow pressure is exerted rather than a quick tamping movement. A very excellent 2-foot tamping stick can be made from a shovel handle. The grip at the end gives a ready purchase for the twisting motion. The opposite end of the stick should be rounded, sandpapered, and soaked for some hours in a lubricating oil or in hot tallow before using.

Second method.—Mix the asphalt and sawdust in a kettle, as described under "First method," over any suitable stove or fire and at any place where it may be most convenient. When thoroughly mixed, dip it out of the kettle and place it on sheet metal to cool in the form of pancake-shaped or biscuit-shaped lumps, whichever form may be the most conveniently used or handled. The sheet metal may be greased or not. The asphalt mixture can be removed when cold by applying a blast torch

to the back of the sheet metal if necessary. Another and often more convenient way of preparing the lumps is to drop the hot mixture into molds made in the ground or in sand and brush off the dirt or sand when the lumps are cold. These lumps of asphalt and sawdust can then be transported wherever they are to be used, or they can be stored indefinitely for future use. When filling a cavity they may be used whole or broken into pieces. A blast torch may be used to soften the surface of the lump before it is pressed into place in the cavity and nailed firmly to the wood, or the lump may have nails driven into it and then partially or completely dipped into melted asphalt and immediately nailed into the cavity. All the lumps should be nailed firmly in place. Small sheets of wire netting, burlap, or canvas often can be nailed or stapled over different layers of the asphalt mixtures with good results; preferably so they will not show on the surface when finished. This operation, perhaps with slight modifications, is repeated until the whole cavity is filled. When the blast torch is used in the interior of the cavity care should be taken that the cambium is not overheated.[13]

After all the decayed matter has been removed and the cavity sterilized and waterproofed, there is no immediate danger in delaying subsequent operations if for any reason such delay seems necessary or desirable. Moreover, it is unnecessary to put all the filling compound into the cavity the same day, or the same week, or even the same month. After asphalt mixtures have cooled, the hot sticky surface can be restored by passing a hot iron over it or by protecting the cambium and using a blast torch. This melting of the surface should be done just before another batch of filling is added, especially when the first method mentioned is used.

When a cavity has been filled by either method, the surface of the filling can be finished off with a hot iron to the level of the cambium, as shown by the dotted lines in figures 9, 12, and 13. If a sufficient quantity of sawdust has not been mixed with the asphalt or if too much clear asphalt has been used to cement the lumps together when the second method is used, the composition will invariably settle away gradually from the top of the cavity. To prevent this, the surface of the finished filling should be covered with canvas, closely woven burlap, thin strips of wood, wire netting, sheet metal, or other suitable covering, and held in place with long nails, screw bolts, or staples that reach into the solid wood at the back of the filling.[14] In shallow fillings a simple way is to drive in closely set long nails, each nail passing through a large metal washer. As a rule, if these washers are closely set no other covering is necessary. When any of these surface coverings are used the outer face should be no higher than the level of the cambium and should be waterproofed with tar, asphalt, or paint.

Care should be taken to avoid bruising or unnecessarily heating the cambium at any time. A very good tool with which to finish the raw

[13] One simple way of preventing this overheating is to have a broad flexible paddle of wood, fiber, or other nonconductor of heat that can be held over the cambium and bark with one hand while the torch is operated with the other. After a little practice the torch will rarely have to be used inside the cavity.

[14] If the bolts, nails, or staples are too thick to be driven through the asphalt without cracking it, they can be heated and slowly pushed through to the wood.

surface near the cambium is a small mason's trowel, the tip of which can be heated for a few seconds at a time in the flame of a blast torch. A tool of this general shape with a thin edge but with more metal at the center is better and will hold the heat longer. For finishing farther away from the cambium, a larger and heavier tool will be more useful; an old-fashioned flatiron does this work efficiently and can be used for this purpose if nothing better is available. If masses of asphalt project too far beyond the contemplated finished surface to be smoothed readily with a hot trowel, they can be cut off with a hot trowel or with a cold chisel and hammer before the surface receives its final smoothing.

Under certain conditions asphalt and sawdust or asphalt and sand, used in combination with cement blocks or with wood (see next heading), will be better than either used separately, and they often are more economical

FILLING CAVITIES WITH WOOD.

Asphalt can be used along with chips, larger blocks, or strips of dry wood (such as laths or scantlings) for filling cavities. When blocks or strips of wood are used as the main filling substance they can be trimmed to fit into various parts of the cavity or the whole cavity and nailed in place. A good way to do this is to trim a block or strip roughly to fit the desired place, then remove it from the cavity and drive the required nails or staples part way through it. At times it may be advisable to use screws or bolts instead of nails or staples. The back of the block or strip and that portion of the cavity in which it is to be placed should be covered with a thick coat of hot asphalt or almost any of the mixtures mentioned above, except perhaps asphalt and chips, and the strip nailed in place. A long heavy nail set (or center punch or saddle punch) will be useful in driving the nails or staples into the strips. The blocks or strips of wood need not be very carefully fitted, because the asphalt mixtures, particularly asphalt and sawdust, will fill practically all spaces between them. Preferably the grain of the blocks or strips should run lengthwise of the trunk and extend the entire length of the cavity, at least when near the surface. In large cavities a strip or layer of strips an inch or two thick can first be placed in the back of the cavity and then the building up done mainly from the sides (fig. 17). If the filling is planned so that there will be an unnailed but thoroughly asphalted closely fitting joint extending the length of the cavity and from the outer surface back to the layer of strips first nailed to the back of the cavity (see fig. 17, *a*–*c*), there will be practically no danger of the filler pulling away from the sides of the cavity as a result of a sudden drop in temperature and consequent contraction of the sapwood. In such a filling the opening, if it comes, will be along the line of least resistance, which in this case will be, almost invariably, the unnailed joint lengthwise of

the filling. In section this joint may be a straight or a zigzag line, preferably the latter. As the crack closes, the asphalt will usually cement the two edges of the joint together again; but even if it does not, both surfaces of the crack still will be covered with waterproof asphalt.[9] If the strips of wood used in the cavity are creosoted before they are put in place, the danger of infection as a result of wetting is still further reduced. The exposed surface of the completed filling should be smoothed off at the level of the cambium, so as to conform more or less closely with the shape of the trunk (fig. 17), and finally painted with hot asphalt, coal tar, or paint of any desired color.

For keeping the asphalt melted some sort of heater will be required. In most cases one that is readily portable will be most useful, for the asphalt can usually first be melted over some less portable heater or stove and the portable heater used merely to keep the asphalt melted while it is being used. Often it will be most convenient to have a rather small heater, such as some blast torch or a plumber's or tinsmith's stove; possibly one that can be suspended by a padded wire from a limb of the tree. A galvanized-iron pail with a capacity of about 10 quarts may be useful for this purpose. The bail socket should be riveted to the pail. With a little ingenuity one of the heaters mentioned above can be altered so that it can be suspended by means of two long hooks to the bail sockets of the pail or to the top of the pail and the pail and the attached heater carried about by the bail, yet the two can readily be separated if desired. The pail and heater can be suspended from the limb of a tree by a padded hook, or the heater can stand on a board on the ground and the pail be set on top of it.

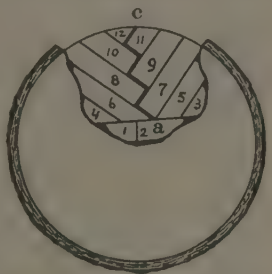

FIG. 17.—Section of a tree cavity filled with strips of wood. The numbers on the strips indicate the order in which they are inserted. No nails are driven across the zigzag line *a-c*.

Oftentimes it is neither necessary nor desirable to completely fill a cavity; or perhaps the necessary time to complete the work promptly is not available. Under such conditions the cavity can be cleaned out, sterilized, and waterproofed and then strips of waterproofed wood nailed along the edges of the cavity, the outer edge of the strip being at the cambium line (fig. 10). In most cases if this strip is a half inch thick it will serve for some time to prevent the new callus wood and bark from rolling inward into the cavity, and before the new growth has reached across it another strip can be nailed over it or the cavity completely filled, perhaps with asphalt

[9] If the wood strips used are soft or easily split, it will be safer to use coal tar in this joint, as cold asphalt will not penetrate the wood to glue it before the asphalt will yield. If the wood should split, the cracks should be filled with coal tar.

and sawdust. If this method is followed it will be necessary temporarily to fill and waterproof the small pocket back of the strips at

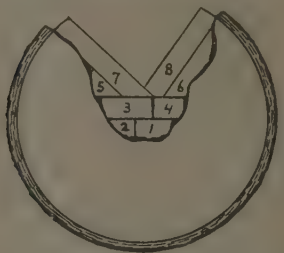

FIG. 18.—Section of a tree cavity partially filled with strips of wood. The numbers indicate the order in which the strips are inserted.

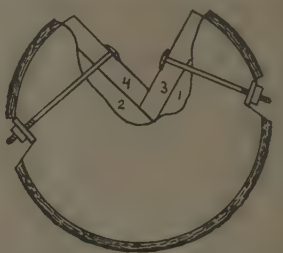

FIG. 19.—Section of a tree cavity partially filled with strips of wood; these are bolted to the walls of the cavity. The numbers indicate the order in which the strips are inserted.

the bottom of the cavity, using wood or some plastic substance so that it will not hold water.

If it is impracticable or inconvenient to use hot asphalt and sawdust between the strips of wood in filling a cavity a substitute can be found by mixing sawdust with creosote and asphalt,[16] or with coal tar, or even with paint. When any of these mixtures is used the strips of wood may have to be trimmed to fit more closely, as such mixtures will not so readily and permanently fill large spaces between the strips as will the thicker asphalt mixtures. Perhaps the best general substitute for the heavy asphalt is a mixture of coal tar and sawdust. This mixture does not necessarily have to be heated during any part of the operation unless the work is done in very cold or freezing weather. It is better, however, to have the tar hot when the sawdust is mixed with it. No definite proportion for the tar and sawdust can be recommended, because the quantity of each ingredient is largely dependent upon the grades of sawdust and tar that are used. In his own work the writer has found that 1 part of dry sawdust by weight to 3 or 4 of coal tar or 3 to 4 parts of dry sawdust by bulk to 1 of coal tar gives a mixture of about the right proportions. The mixture should be stirred (preferably when

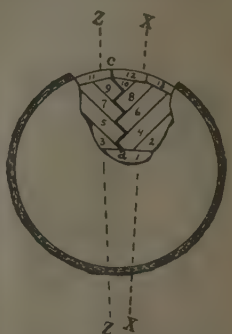

FIG. 20.—Section of a tree cavity filled with strips of wood, with a thin surface layer of strips (11, 12, 13). The broken line *x–x* indicates where a bolt, when necessary, should be located to hold the ends of a filling, as indicated in figure 21. Occasionally it may be necessary to place bolts at both *x–x* and *z–z*. No bolt should pass through the annulus *z z* as [illegible] *c*.

[16] For directions for mixing creosote and asphalt, see p. 9.

warm) until it is of an even consistency—somewhat granular but sticky and pasty. When put in the cavity it should stick there after a little pressure or after tamping with an oiled or moistened stick, but should not be thin enough for the tar to ooze out, at least not until the mixture is compressed by nailing or stapling the wood strips firmly in place over it. It will be advisable to paint the exposed wood, the strips that have been fastened in the cavity, and the back of the strip that is to be inserted, using clear coal tar, before inserting the sawdust and tar mixture.

Generally some such arrangement of strips as is shown in figures 17, 18, and 19 will be found most advantageous in most cavities, as such an arrangement usually permits greater freedom in driving the nails or staples or in placing the screws or bolts in position through the strips. The edge of the strips at the surface should be trimmed off in a line with the cambium, as shown in figures 17 and 21, or the strips may be trimmed back to a line behind the cambium and one, two, or more thin strips of sufficient thickness to bring the surface to the cambium line nailed, screwed, or bolted over it to form an outside layer, as shown in figure 20. The order in which the strips should be placed in the cavity is indicated by the order of the numbers in figures 17, 18, 19, and 20. In long fillings, particularly in flexible branches, a bolt and metal washer near each end of the filling and another at the center will prevent the ends or center working loose. Figures 19, 20, and 21 with their legends will explain the details of placing the bolts and washers.

FIG. 21.—Surface view of a tree cavity filled with strips of wood, as shown in section in figure 17; the surface has not yet been waterproofed. The broken lines show the position of the bolts and the broad washers. The washers should be of heavy iron and wide enough to reach across all the strips at the point where they are placed. The bolts should not pass through the unnailed joint (*a–c*) indicated in figures 17 and 20.

GUYING.

Closely associated with the work already described, and often an indispensable adjunct, is the guying of limbs to prevent the splitting of the crotches or to check splitting that has already started.

A simple method of guying a crotch is to place a hook or ring bolt through each limb, with the hooks or rings in the two limbs toward each other and from 3 to 10 feet or more above the crotch (depending upon the size, position, and length of the limbs), and to tie these hooks by means of a strong wire, wire cable, or chain (figs. 22 and 23). Three or more adjoining limbs may be guyed collectively. The

precautions already mentioned on pages 15 and 16 should always be followed, so far as they apply to boring and tarring the hole and countersinking the washers of the bolts.

A turnbuckle rod or bolt is often better than a cable or wire when the guy is to be kept perfectly taut at all times. Furthermore, the rod or bolt permits a ready tightening of the guy within certain limits, should it later become advisable. If for any reason the guy is to be placed within a foot or two of the crotch, a single long bolt can often be used to better advantage, and sometimes a single long bolt can be used in place of a cable, a chain, or a turnbuckle rod where the guyed limbs are not likely to twist much as they sway in the wind.

FIG. 22.—Side view of limbs, showing the proper method of guying them above a weak or split crotch. The wire, cable, or chain guy is shown at *a*.

Occasionally it may become necessary to guy a whole tree in order to prevent the breaking of the trunk when an unusually large cavity leaves only a thin shell of sound wood or to prevent a tree that has recently been set from tipping over before its roots have become well established. This can be accomplished by attaching four guy wires or ropes to the tree about half way from the ground to the top of the tree and having these slant downward at an angle of about 45° to four stout posts set firmly in the ground about equidistant around the tree (e. g., on the north, east, south, and west sides of the tree). If the guying is for temporary purposes only, two broad bands of leather or stout canvas or other strong material, each long enough to make a loop at least twice the diameter of the trunk or limb to be encircled and 4 to 6 inches wide, may be passed around the tree or some favorably situated limb and two adjoining guys attached to each loose loop. If a permanent guying is needed, two eyebolts (or hook bolts) can be placed through parallel creosoted holes in the trunk or limb about halfway up the tree, one 6 inches or more above the other. The eye of one bolt should be on the opposite side of the tree from the other. Two guys from two adjoining posts are attached to each eyebolt, the latter pointing halfway between the two posts to which the guys are to be attached (fig. 24). The chafing of a limb against a guy should be prevented by padding the guy wire with a piece of garden hose or the limb with burlap, if the guy can not be so placed or braced as to clear all limbs.

FIG. 23.—Sectional view of the limb of a tree, showing the details of placing an eyebolt of the type shown in figure 22: *a*, Bolt; *b*, bark; *w*, wood.

Limbs or trees should never be guyed by passing wires, chains, or ropes tightly around them. These may eventually strangle the portions above the encircling band. Encircling fence wires, telegraph wires, or clotheslines may act in the same way, killing all parts of the tree beyond the ligature if they remain tightly drawn around the limb or trunk for any great length of time—often in less than a year.

WHEN REPAIR WORK MAY BE DONE.

As a general rule, tree surgery can be undertaken safely at almost any time of year when the sap is not running too actively and the weather is not cold enough to freeze cement, if this is being used. In most trees the sap will interfere with the work only while the buds and leaves are expanding in the spring. Cement work will be ruined if it is frozen before it is set. It is not likely to be injured by frost after setting for a few days.

WHAT TREES ARE WORTH REPAIRING.

Most trees with only a few dead limbs are unquestionably worth attention. Others that have many dead limbs or decayed areas may not be worth the expense of repairing them, particularly if they are rapid-growing short-lived trees. This point should be considered very carefully before any repair work is undertaken. In any event a diseased or insect-infested tree should not be allowed to remain as a menace to near-by trees which are in a more healthy condition or entirely healthy. It should have all diseased or insect-infested bark, wood, or leaves removed and all freshly cut surfaces properly treated, or the entire tree should be removed. The diseased portions should be burned immediately. No one can decide better than the owner whether a tree is worth the expense of trying to save it, because the actual commercial value of an ornamental or shade tree usually has nothing to do with the decision. It is generally a question of esthetic value, or historic associations, or rarity of species. A man who has had experience in repairing mutilated or diseased trees may be able to say definitely whether it is possible to save the tree, but the owner, who has to pay the bill, is the one who will have to decide whether the tree is worth the cost of repairing it. Often the owner will be better satisfied in the end to have a badly diseased or mutilated tree replaced by a healthy perfect one. In expert hands the moving of large trees is no longer a hazardous undertaking.

FIG. 24.—Sectional view of a tree trunk, showing the details of placing bolts for permanently guying a tree to the ground. This method of placing a bolt is used also in guying three or more limbs together. The broken lines indicate the guy wires.

COMPLETED WORK NEEDS WATCHING.

With the completion of repair work tree owners often fail to realize the importance of keeping close watch of their trees in order that defects which appear in the work may be remedied promptly and that new injuries elsewhere on the tree may have immediate attention. If a tree is of sufficient value to warrant proper and careful treatment, it certainly is worth the slight expense of subsequent annual or biennial inspection and the immediate repair of newly discovered injuries at a time when the expense necessary to keep the tree in good condition will be comparatively small.

PERSISTENCE OF SCARS.

It should be borne in mind that scars where large limbs have been removed or large cavities filled will be unsightly spots for years, even under the best of conditions. If the scar is a large one, it may never entirely heal over and consequently may remain a permanently conspicuous defect. It might so happen that a particularly large scar or filling would be too unsightly and conspicuous to please the owner. Here, again, greater satisfaction may be realized in the end by having the diseased tree replaced with a healthy one.

COMMERCIAL TREE-SURGERY WORK.

If a tree owner prefers to employ a commercial tree surgeon to attend to his trees it is well to have a definite written contract concerning at least certain important phases of the work, in addition to specifying the price and methods of payment. Besides the type or types of filling to be used in cavity work the following are suggested as points to be incorporated in the contract:

(1) No climbing spurs shall be used on any part of a tree.
(2) The shoes worn by the workman shall have soft soles.
(3) In cavity work all diseased, rotten, discolored, water-soaked, or insect-eaten wood shall be removed and the cavity inspected by the owner or his agent before it is filled.
(4) Ordinary commercial shellac shall be applied to the cut edges of sapwood, bark, and cambium within five minutes after the final trimming cut is made or as soon afterwards as the surface becomes dry.
(5) All cut surfaces shall be painted with shellac or commercial creosote, followed by thick coal tar or asphalt.
(6) The contractor shall repair free of expense any defects that may appear in the work within one year.

Under certain conditions various modifications of these suggestions may be advisable, but alterations in Nos. 1, 2, 3, and 6 should be made with caution. If certain crotches are split or particular limbs on some trees need guying, it may be well to include these items in the contract. At times it may be desirable to include a statement of

just what limbs shall be removed from particularly choice trees, and some provision should always be made for the regular inspection of the trees every one or two years unless the owner prefers to do this himself. The best results can generally be attained when payment is based upon the amount of work done, plus the cost of material used. Probably most persons, however, will prefer to have the trees examined and a definite contract price agreed upon before any work is undertaken.

CONCLUSIONS.

At present tree-repair work has not received the recognition and approval from tree owners that it deserves. This may be due at times to unfavorable experiences with dishonest or ignorant tree surgeons, at other times to the reluctance of the owners to spend much money in preserving their trees, or from their ignorance of the benefits that may result when tree-repair work is properly done. Reliable tree surgeons are doing much in a practical way to educate the public as to the benefits of tree-repair work. Unfortunately, the unscientific or dishonest work of some others still is doing much to offset it.

A few States have laws regulating tree-repair work on a commercial basis. This is a decided step toward the betterment of tree-surgery methods.

The Department of Agriculture invites correspondence concerning methods in tree-repair work and will be prepared to advise for or against any particular method so far as experience and the results of experiments will permit. By cooperation of this sort tree-repair work ought ultimately to deserve and attain a much higher position in the estimation of the general public than it now holds.

Finally, tree owners are urged to remember at all times that the necessity of tree-repair work 15 or 20 years hence may be reduced very materially by promptly attending to the fresh injuries of to-day.

PUBLICATIONS ON ALLIED TOPICS AVAILABLE FOR DISTRIBUTION.

No publications are sold by the Department of Agriculture; therefore do not send money to this Department.

Copies of publications listed herein will be sent free upon application to the Chief of the Division of Publications, Department of Agriculture, Washington, D. C., as long as the supply lasts. The editions of some of these listed are exhausted.

When the Department supply is exhausted, available publications can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., by purchase only and at the prices noted here.

Send all remittances to the Superintendent of Documents direct. His office is not a part of the Department of Agriculture.

Blister Rust, White Pine. Pp. 15, pl. 1, figs. 5. (Farmers' Bulletin 742.)

Cedar, Red, Diseases. Pp. 22, pls. 7, figs. 3. (Division of Vegetable Physiology and Pathology Bulletin 21.) Price 10 cents.

Chestnut Bark Disease. Pp. 10, pls. 4. (Separate 598, Yearbook for 1912.) Price 10 cents.

Chestnut Bark Disease, Control. Pp. 24, figs. 4. (Farmers' Bulletin 467.) Price 5 cents.

Chestnut Bark Disease, Extent and Importance. (Forestry, Miscellaneous Publication.) Price 5 cents.

Chestnut Bark Disease, Japanese, Immunity. Pp. 4. (Bureau of Plant Industry Bulletin 121, part 6.)

Chestnut Bark Disease, Status. Pp. 14, pl. 1, fig. 1. (Bureau of Plant Industry Bulletin 141, part 5.)

Chestnut Timber Killed by the Bark Disease, Uses. Pp. 24, figs. 8. (Farmers' Bulletin 582.) Price 5 cents.

Chestnuts and Oaks, Death of, Due to Armillaria mellea. Pp. 9, pls. 2. (Department Bulletin 89.) Price 5 cents.

Coniferous Nursery Stock, Blights of. Pp. 21. (Department Bulletin 44.) Price 5 cents.

Coniferous Seedlings, Damping-off, Control. Pp. 32, pls. 2, fig. 1. (Department Bulletin 453.)

Coniferous Seedlings, Damping-off, Treatment. Pp. 8. (Bureau of Plant Industry Circular 4.) Price 5 cents.

Crown-Gall of Plants, Cause and Remedy. Pp. 215, pls. 36. (Bureau of Plant Industry Bulletin 213.) Price 40 cents.

Crown-Gall, Plant Cancer, Structure and Development. Pp. 61, pls. 109, figs. 2. (Bureau of Plant Industry Bulletin 255.) Price 50 cents.

Disinfectants, Injury to Seeds and Roots in Sandy Soils. Pp. 35, pl. 1, figs. 2. (Department Bulletin 169.) Price 5 cents.

Farmstead, Beautifying the. Pp. 65, figs. 66. (Farmers' Bulletin 1087.)

Forest, Hardwood, Northern: Its Composition, Growth, and Management. Pp. 80, pls. 15, fig. 1. (Department Bulletin 285.) Price 20 cents.

Fungi, Mushrooms and Other Common. Pp. 64, pls. 38, fig. 1. (Department Bulletin 175.) Price 30 cents.

Fungicides and Their Use in Preventing Diseases of Fruits. Pp. 32, figs. 17. (Farmers' Bulletin 243.) Price 5 cents.

Home Grounds, Beautifying the. Pp. 24, fig. 8. (Farmers' Bulletin 185.) Price 5 cents.

Jack Pine, Pathology, Observations. Pp. 10, pl. 1, figs. 4. (Department Bulletin 212.) Price 5 cents.

Larch Mistletoe: Some Economic Considerations of Its Injurious Effects. Pp. 27, figs. 13. (Department Bulletin 317.) Price 5 cents.

Mistletoe Injury to Conifers in the Northwest. Pp. 39, pls. 4, figs. 27. (Department Bulletin 360.) Price 15 cents.

Mistletoe Pest in the Southwest. Pp. 39, pls. 2, figs. 7. (Bureau of Plant Industry Bulletin 166.) Price 10 cents.

Pine, Disease Caused by Cronartium pyriforme. Pp. 20, pls. 2, fig. 1. (Department Bulletin 247.) Price 5 cents.

Pine, White, European Currant Rust. Pp. 4. (Bureau of Plant Industry Circular 38.) Price 5 cents.

Pruning. Pp. 35, figs. 25. (Farmers' Bulletin 181.)

Red Gum, Sap-Rot and Other Diseases. Pp. 37, pls. 8. (Bureau of Plant Industry Bulletin 114.) Price 15 cents.

Slash, Rotting in Arkansas, Investigations. Pp. 15. (Department Bulletin 496.)

Smelter Fumes, Injury to Vegetation. Pp. 23, pls. 6, fig. 1. (Bureau of Chemistry Bulletin 89.) Price 5 cents.

Smelter Wastes, Injury to Vegetation and Animal Life. Pp. 63, pls. 9. (Bureau of Chemistry Bulletin 113.) Price 10 cents.

Street Trees. Pp. 58, figs. 37. (Department Bulletin 816.) Price 15 cents.

Timber Rot Caused by Lenzites sepiaria. Pp. 46, pls. 4, figs. 3. (Bureau of Plant Industry Bulletin 214.) Price 10 cents.

Timber Storage Conditions in Eastern and Southern States with Reference to Decay Problems. Pp. 43, pls. 10, figs. 41. (Department Bulletin 510.) Price 20 cents.

Tree Surgery, Practical. Pp. 28, pls. 7. (Separate 622, Yearbook for 1913.) Price 10 cents.

Walnut Blight in the Eastern United States. Pp. 8, pls. 2. (Department Bulletin 611.) Price 5 cents.

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